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Imaging intra-breath cyclic changes in pulmonary blood volume: effect of ventilator settings

Rationale: Despite the importance of dynamic changes in the regional distributions of gas and blood during the breathing cycle for lung function in the mechanically ventilated patient, no quantitative data on such cyclic changes is currently available.

Methods: We used a novel gated synchrotron CT-imaging with K-edge subtraction technique to quantitatively image regional lung gas (Vg), tissue density and blood volume (Vb) in 6 anaesthetized, paralyzed and mechanically ventilated rabbits with normal lungs. Images were repeatedly collected during ventilation and steady-state inhalation of 50% Xe, or iodine infusion. Data were acquired in a dependent and non-dependent image level, at an end-expiratory pressure of 0 (ZEEP) and 9 cmH2O (PEEP), and a VT of 6 (VT1) or 9 ml/kg (VT2) at an I:E ratio of 0.5 or 1.7 by applying an end-inspiratory pause (EIP).

Results: A video showing dynamic decreases in Vb during inspiration is presented. Vb decreased with PEEP (p=0.006; p=0.036 vs. VT1-ZEEP and VT2-ZEEP, respectively) and showed larger oscillations in the dependent image level , while a 45% increase in VT did not have a significant effect. End-inspiratory Vb minima were reduced by an EIP (p=0.042, p=0.006 in non-dependent and dependent levels, respectively). Normalized regional gas to blood volume ratio increased upon inspiration.

Conclusions: Our data demonstrate for the first time, within-tidal cyclic variations in regional pulmonary blood volume. The quantitative matching of regional gas and blood volume improved upon inspiration under ZEEP, suggesting a possible link between cyclic changes in regional gas and blood distribution and previously-described PaO2 oscillations, under controlled ventilation.

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